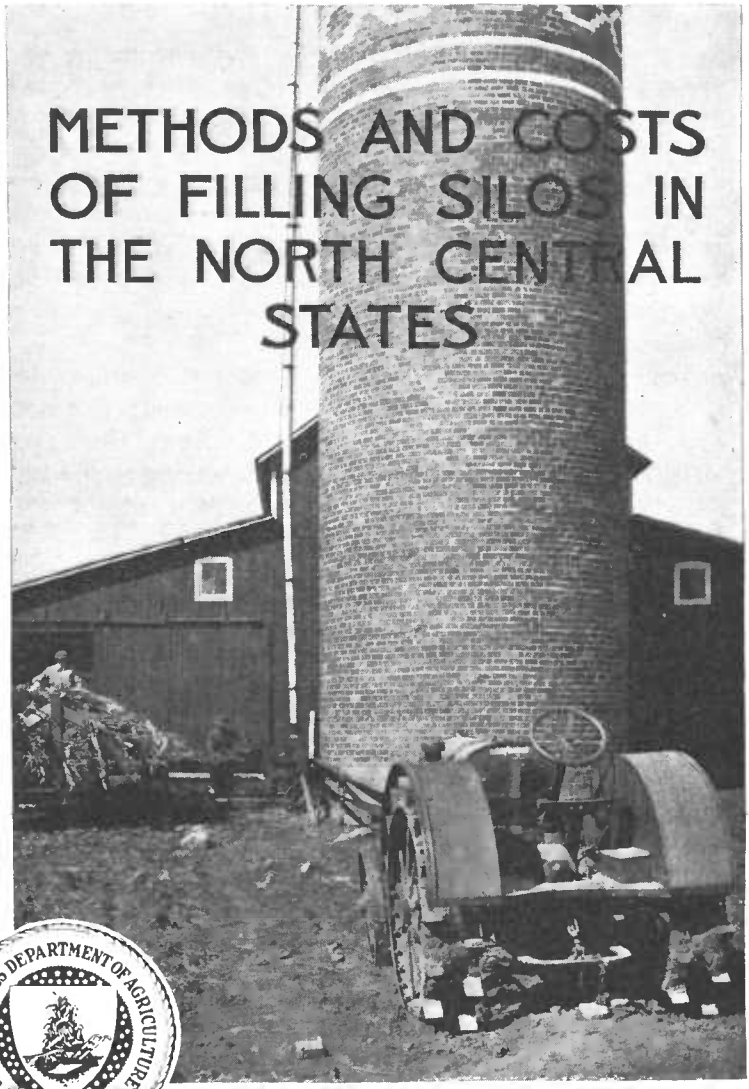
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1725

METHODS AND COSTS OF FILLING SILOS IN THE NORTH CENTRAL STATES



SILO FILLING is an important task on many farms. Silage would be a more common feed were it not for the expense and labor required in filling the silo. Improvements in methods and equipment which decrease the expense and lessen the labor are important in determining the cost of farm operation.

Two types of equipment are used in filling silos—the stationary cutter, which cuts the corn into small pieces and elevates it into the silo, and the field silage harvester which cuts the standing corn and cuts it into small pieces in one field operation. With the latter equipment a blower elevates the finely cut corn into the silo. When stationary cutters are used the corn may be cut in the field by hand or by binders. If binders are used the bundles of corn may be dropped on the ground or loaded directly on the wagon by means of an elevator attachment.

The cost of filling a silo varies with the type of equipment. The average cost in Illinois, according to the study on which this bulletin is based, was $1.49 per ton on farms where stationary cutters were hired, $1.41 on farms where stationary cutters were owned, and $1.31 per ton on farms where field harvesters were used.

Using a field harvester involves substituting power and equipment for part of the man labor used in filling the silo with the stationary cutter. On an average, the investment in equipment was more than twice as high, and twice as much tractor power was used when the filling was done with field harvesters, but 21 percent less man labor and 27 percent less horse work were used. Cash costs made one half the total when stationary cutters were hired, one third when they were owned, and one forth when field harvesters were used. One of the chief advantages of the field harvester is the possibility of using family labor or labor that could not be used so well around a stationary cutter, thus reducing the total cost and the cash cost of filling.

Washington, D.C. Issued May 1934

METHODS AND COSTS OF FILLING SILOS IN THE NORTH CENTRAL STATES

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INTRODUCTION

The corn crop from approximately 4,000,000 acres is converted into silage in the United States each year. This method of harvesting and storing the corn crop is used in all parts of the country but is most common in the dairy regions, and, to a lesser extent, in beef-cattle-feeding areas. Corn is cut for silage on approximately 375,000 farms or on an average of about 1 farm in 17. Wisconsin leads in total number of farms on which silage is fed—more than 90,000, or about one third the total number of farms. Twenty-five percent of the farms in New York and 20 percent of those in Minnesota reported this method of harvesting corn in 1929. Corn is cut for silage on more than one half the farms in the dairy area in northern Illinois.

The presence of the European corn borer in the United States has caused more attention to center on equipment and methods for harvesting corn. The continued spread and increased numbers of borers will necessitate the adoption of farm practices by which the entire corn plant is fed to livestock or otherwise disposed of. Cutting for silage or fodder is an effective method of controlling the borer if the corn is cut at the ground surface, and may be the most economical method of control where the silage or fodder can be fed to dairy or beef cattle.

Improvements in silo-filling machinery and the development of new methods have eliminated much of the drudgery of silo filling and, with the increased use of farm tractors, have been important factors in promoting individual farm ownership of such machinery. These developments have made the choice of equipment and methods more difficult for the individual farmer, however, since much labor is replaced by power and equipment. The farmer must consider, with respect to conditions on his farm, the ownership of silo-filling machinery, the type and size of equipment, and the size and organization of the crew. On farms on which the necessary equipment is already owned there is little alternative so far as machine ownership or type

[1] Acknowledgment is due M. A. Crosby, Division of Farm Management and Costs, for assistance in preparing the manuscript.

of equipment is concerned since the cost of making a change would more than offset any advantage gained. On farms on which no equipment for filling is owned, or on which the old equipment is so depreciated that it cannot be used further, a choice must be made between buying new equipment or hiring a machine, and if the operator decides to purchase new equipment the choice of type and size is important. The most economical size and organization of the crew may vary from farm to farm, and from year to year on the same farm, with changes in the supply of labor, relative prices of labor and power, and other factors.

SCOPE AND PURPOSE OF STUDY

This study is based on data collected in 1928 and 1929 by the Department of Farm Organization and Management, University of Illinois, in cooperation with the Bureau of Agricultural Economics, United States Department of Agriculture. Records of the cost of filling upright silos were obtained on 87 farms in Illinois on which stationary cutters were used and on 118 farms on which field harvesters were used. Practices and equipment in silo filling have not changed appreciably since the data were gathered. It is believed the conclusions are approximately applicable to most parts of the country where upright silos are used. They are particularly applicable to conditions in the North Central States.

Since then the wages of farm labor have fallen to about 48 percent, the cost of horsepower to about 50 percent, and the cost of tractor power to 85 percent of the rates obtaining during the years of the study. These changes and changes in the future should be taken into account by farmers in using the figures given in this bulletin.

The purpose of this bulletin is (1) to show the elements of cost involved in filling upright silos by different methods and practices, (2) to show the relative importance of these elements of cost and the factors affecting them, and (3) to present a basis for selecting and combining them in such manner as best to fit conditions on the individual farm. As it is assumed that the farmer is committed to the practice of making and feeding silage, no attempt is made to show its advantages or disadvantages. Nor is the cost of producing the corn crop considered since in most areas the methods used in producing silage corn are similar to those used in producing corn for grain.

TYPES OF EQUIPMENT AND INITIAL COST

Two methods in which the equipment is entirely different are used for filling silos in the United States. The most common method is that in which corn is cut in the field, hauled to the silo, and cut up for silage with a stationary cutter. The field silage harvester was first put on the market in 1918 and is not widely used. It cuts the standing corn and chops it into silage lengths in one operation, after which the material is elevated into the silo by means of a blower (figs. 1 and 2).

The stationary cutters are all of the same general type, varying only in mechanical construction, and, more important, in size. There are wide variations, however, in the equipment and methods used in cutting the corn in the field and hauling it to the silo. The maximum cutting capacity of stationary cutters varies largely with the size, but on most farms the rate of filling depends on the number of men hauling the corn to the silos. The field harvester is made in only one size, and

the only equipment used with it are box wagons for hauling the cut corn to the silo and a blower to elevate it. The small amount of strenuous labor required in filling with this machine makes it possible to utilize a class of labor that cannot be used around a stationary cutter.

The newer field harvesters are drawn and operated by a tractor equipped with a power-take-off device. They have proved more efficient and satisfactory than the earlier machines, which were drawn by horses, the cutting mechanism being operated by a gasoline motor mounted on the frame of the machine. The older type of cutter was used on nearly two thirds of the farms studied, and there seemed little difference in the cost of filling.

The amount of capital required to buy silo-filling equipment is relatively large in relation to the amount of use that can be made of such

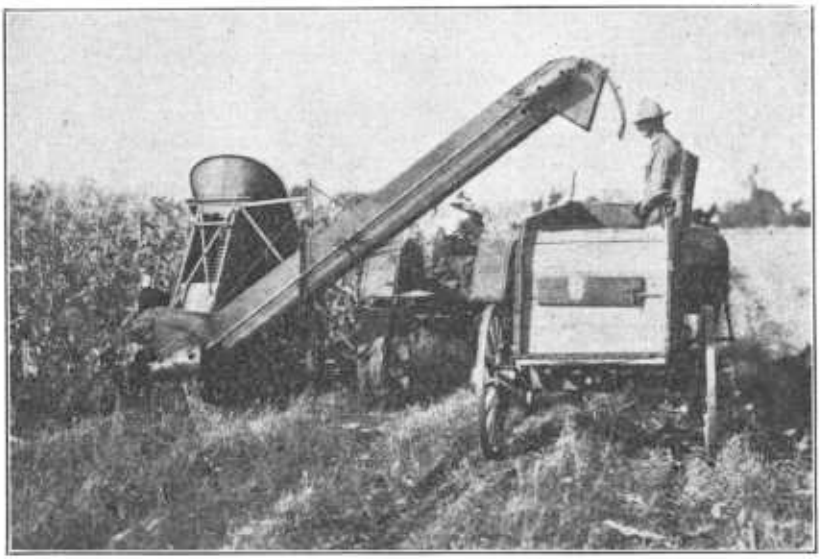

FIGURE 1.—Cutting corn with a field silage harvester.

equipment on many individual farms. Insufficient capital, or alternative uses for that which is available, lead many farmers to hire custom outfits to fill their silos, or leave little choice as to type of equipment to be purchased. This is particularly true in the case of tenant operators, whose capital is closely limited or whose terms of occupancy may be uncertain.

The amount of capital required depends on the methods and equipment used in cutting the standing corn, and on the type of equipment used in cutting the corn into silage length. The average initial cost of the silo-filling equipment used on the farms studied was as follows: Stationary cutter, $375; corn binder without elevator, $175, and with an elevator, $225; field harvester, $625; blower, $225. Most of the equipment used on these farms was bought during the 8 to 10 years previous to the time the study was made. Small stationary cutters may be bought for less, however, and if the corn is cut by hand the necessary investment per farm may be kept at a much lower figure than is indicated by these prices.

EQUIPMENT OWNERSHIP

Private ownership of silo-filling equipment has become common, and the relatively high investment has been justified by a saving in labor costs and amount of time used in filling. In many instances the necessary capital is supplied by two or more farm operators, and the equipment is owned and operated cooperatively. In localities in which silos are common the necessary equipment may be hired, frequently at less cost than if a machine were owned. In addition to

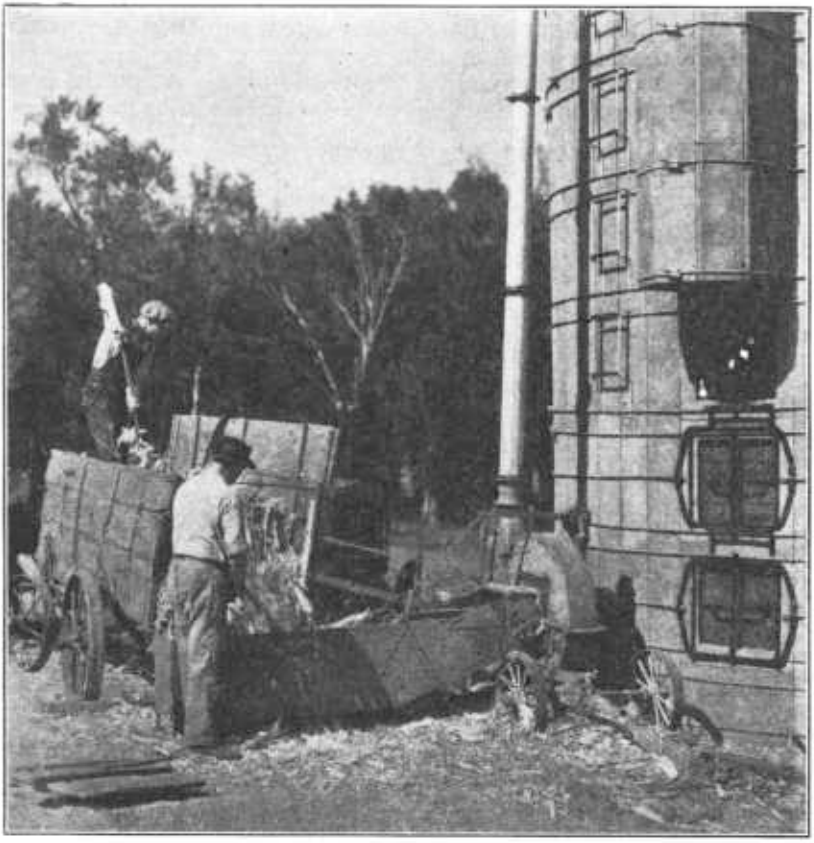

FIGURE 2.—Elevating silage material cut by a field silage harvester. On many farms a wagon hoist is used to lift the front end of the wagon, allowing the material to slide into the blower hopper.

regular custom outfits operated entirely for profit, many farmer-owned machines are used on neighboring farms in exchange for power or labor, and some custom work often is done to provide profitable work for the regular labor and at the same time reduce the overhead cost of filling the home silo.

The farm tractor has been an important element in promoting farm ownership of belt-operated equipment. Many tractors are bought with a view to reducing the cost of hiring power and equipment for belt work and with the knowledge that they would otherwise not

be used enough to justify the investment. If power for filling silos has to be hired its cost may more than offset any advantage of owning silo-filling equipment.

Cooperative ownership of equipment often solves the problem of securing the initial capital and of providing labor and power for silo filling. Overhead costs decrease as the amount of corn cut by each machine increases, and the investment per farm is lower when the machine is owned cooperatively. The number of farms included in such an agreement, however, should be no more than are needed to provide the necessary capital, labor, and power.

Stationary cutters were hired on nearly half of the farms in this study on which this type of machine was used, and most of those hired were regular custom outfits. They are more generally used in custom filling than field harvesters because of greater flexibility in the possible rate of filling and because of the smaller investment. Field harvesters were hired on several of the farms, but none could be classed as regular custom machines.

The cost of hiring a custom machine represents a definite cost of operating the farm and takes the place of depreciation, interest, repairs, and shelter costs on the same equipment if owned on the farm. Owners of custom outfits charge more for the use of their machines than barely enough to cover these costs, but because of the large quantity of silage cut by many custom machines during the season, the cost per ton of silage to the silo owner often is less than with a machine that is used only on 1 or 2 farms even though it is efficiently operated.

Custom machines often are difficult to get at the time when the corn should be cut for silage, and, since they usually are large, much hired labor must be used in order to keep the custom charge as low as possible.

The amount of time required to fill the silo is a common basis for determining the custom filling charge. The rate varies, but the most usual charge in 1928 and 1929 was $4 per hour, plus the cost of fuel, for the cutter and tractor and the wages of two men. Only the time that the machine is in position and ready to fill is counted; the time required to set the machine and that lost through breakdowns is not included in the filling time. This basis for payment is probably the most equitable to both parties. The silo owner usually provides a large crew in order to complete the filling in as short a time as possible, and this in turn enables the machine owner to fill a larger number of silos during the season.

On some farms the custom charges are based on the estimated capacity of the silo, or a flat charge is made for the entire job. These bases for payment often lead to disagreement since the capacity of the silo varies with the amount of tramping, the condition of the corn, and other factors, and the time required to fill the silo depends on the size of the crew provided by the silo owner.

CAPACITY OF EQUIPMENT AND POWER REQUIREMENTS

The quantity of silage material cut during the season, the number of men, and amount of time available for filling silos, are important considerations when selecting equipment. If the equipment is to be

used on several farms and a relatively large amount of labor is readily available, a machine with a high cutting capacity should be used in order to complete the job before the corn is too dry to make good silage, and to use the available labor efficiently. If only a small acreage is to be cut on 1 or 2 farms, the rate of filling is less important than is the efficient use of a small crew of men. In that case a small machine should be selected.

The maximum capacity of stationary cutters depends on the size of the cutter, length of cut, number of knives, and the speed at which the cutter is driven. Tests have shown, however, that most medium-sized cutters are operated at not more than 40 to 60 percent of their full capacity. The maximum rate of cutting, even with a 14-inch machine, is limited by the rate at which the corn can be fed into the machine and not by the ability of the machine to cut and elevate the corn. With a small machine, or with large machines poorly adjusted, the cutting capacity of the machine may be the limiting factor in determining the rate of filling.

On the farms studied, there appeared little relationship between the size of machine and rate of filling, chiefly because the size of the crew was not determined by the size of the machine. There was a distinct relationship, however, between the size of crew and rate of filling. On farms where crews of less than 10 men were used, an average of 5.4 tons was cut per hour; where 10 to 14 men were on the crew, an average of 8.2 tons was cut per hour, and where 15 to 19 men were used, the average rate of cutting was 10 tons per hour.

The rate of cutting with the field harvester depends on the yield of silage material per acre and on the ability of the operator to keep the machine running steadily. An average of about 5.5 tons of corn was cut per hour on the farms studied, and although the amount varied from 2.5 to over 15 tons, from 5 to 7 tons was cut per hour on over one half of the farms. As the yield of silage material increases, the machines are forced to travel at a lower speed to enable the cutting mechanism to handle the crop, but the quantity of corn cut per hour increases. The mechanical ability of the operator is more important with this type of filler than with the stationary cutter if maximum speed is to be attained. The field harvester blower easily handles the chopped corn at the silo as rapidly as it can be cut in the field.

Steam engines, tractors, stationary gas engines, and electric motors are used to furnish power for filling silos. The common farm tractor usually furnishes sufficient power except on farms where large stationary cutters and large crews are used. The amount of power necessary to cut at maximum speed with a stationary cutter depends on the size of the cutter, the speed at which it is driven, the height of the silo, and the rate of feeding the cutter. In earlier years steam engines were often used for filling with stationary cutters, but they were used on only 8 percent of the farms studied in 1929. Three-plow, or larger, tractors were used on nearly two thirds of the farms on which the filling was done with a stationary cutter.

Two power units are required in filling with the field harvester—one to pull the cutter in the field and one to operate the blower at the silo. Condition of the ground, size and condition of the corn, and the rate of travel are important factors in determining the amount of power necessary to pull the field cutter. The power requirements of the blower used with the field harvester are similar to, but less than,

that of stationary cutters since no cutting is done with the blower. Nearly two thirds of the power-take-off field harvesters were pulled by 3-plow tractors, while 2-plow tractors were used on about the same proportion of the blowers at the silos. Less power is required to operate the blower than to pull the field harvester, and where both a 2- and a 3-plow tractor were available the larger machine usually was used in the field. Three horses were used to pull most of the motor-mounted field harvesters, but on 10 farms tractors were used. The rate of cutting was about the same on the farms studied where either 2- or 3-plow tractors were used to pull the cutter except where the corn was unusually heavy or dry, or when the ground was soft and wet. Under these conditions the larger tractor was more effective.

The slight differences in the rates of cutting on farms where different sized cutters and tractors were used indicate that neither the full capacity of the cutter nor all the available power is used on many farms. Most efficient operation is obtained only when available power, labor, and equipment are used at near full capacity. This is not always possible, but it should be kept in mind when selecting the equipment and when organizing the crew for filling the silo.

AMOUNTS OF LABOR, POWER, AND MATERIALS USED IN FILLING SILOS

The amounts of labor, power, and materials used in filling silos vary with the equipment used and the method of performing certain parts of the filling process. The average amounts of labor and power used in filling with stationary cutters and with field harvesters on the farms from which data were collected are given in table 1. In many localities, particularly in the eastern dairy region, smaller crews are used and the silo-filling job is spread over a longer period by permitting the cutting and filling equipment to be idle a part of the time.

TABLE 1.—*Average amounts of labor and power used in filling upright silos in Illinois with stationary cutters and with field harvesters, 1928 and 1929*

Item	Farms on which stationary cutters were used			Farms on which field harvesters were used
	Farms where corn was cut in the field by hand	Farms where corn was cut in the field with a binder	All farms	
Farms—number	26	47	[1] 87	118
Corn cut per farm—acres	11.7	18.8	16.1	15.7
Silage made per farm—tons	99	139	121	130
Yield of silage corn per acre—do	8.4	7.4	7.5	8.3
Average size of crew—men	16.6	10.3	12.0	6.8
Amount cut per hour of man labor—tons	.67	.42	.57	.80
Labor and power used per acre:				
Man labor—hours	20.1	11.0	13.2	10.4
Horse work—do	14.5	16.6	16.0	11.7
Tractor use—do	1.21	1.07	1.11	2.3
Labor and power used per ton:				
Man labor—do	2.38	1.49	1.76	1.25
Horse work—do	1.72	2.24	2.14	1.40
Tractor use—do	.14	.15	.15	.28

[1] On 14 farms part of the corn was cut by hand and part with a binder.

Less man labor and less horse work are involved in filling with the field harvester than with stationary cutters, but more tractor power is necessary. Likewise, less man labor is necessary when a binder is used to cut the corn for filling with stationary cutters, but more horse work is used than when the corn is cut by hand. The investment in equipment is also increased, and more materials, such as fuel, oil, and twine, are used when this labor-saving equipment is used.

The process of filling the silo may be divided into four operations for the purpose of studying the costs involved. These divisions are (1) cutting the corn in the field, (2) loading and hauling the corn to the silo and unloading it on the cutter table, (3) operating the cutter or blower and power unit, and (4) tramping the silage in the silo. A fifth, which includes labor in setting up the machine, putting in doors, and general supervision, is often necessary. Each of these operations represents a separate problem in determining the equipment and the number of men used, but each must be considered in its relation to the others in making the final choice of equipment and size of crew.

MAN LABOR

CUTTING CORN IN FIELD

Corn usually is cut with a binder in localities in which relatively large acreages are cut for silage or fodder. Binders eliminate the hard work of cutting corn by hand and have the added advantage in some localities of making it possible to secure hired or exchange labor more easily and at lower rates. Bundle elevators, which convey the bundles directly from the binder to the wagon as the corn is cut, are used on many farms (fig. 3). This attachment, primarily, is a further step toward making silo filling easier and less disagreeable, since more man labor and horse work often are used and the investment in equipment is increased. The use of the elevators, however, increases the quantity of corn hauled by each man.

An average of 5.10 hours of man labor was used per acre in cutting corn by hand on the farms studied; 1.55 hours per acre where the corn was cut with binders and the bundles dropped on the ground; and 1.85 hours where binders were equipped with bundle elevators. Operating at these rates in average corn, one man cuts about 1.6 tons per hour by hand, about 5.4 tons with a binder if the bundles are dropped on the ground, and 4.4 tons if the bundles are elevated directly to wagons. The rate of cutting with binders equipped with bundle elevators is lower than when the bundles are dropped on the ground since the binder must stop while an empty wagon is brought into position to receive the bundles, and often must stop to allow the hauler to arrange the bundles on the wagon, unless an additional man drives the team. Two or three binders often are necessary when elevator attachments are used since then no corn can be cut before filling is started. When corn is cut by hand or a binder without the elevator, it is a common practice to start cutting a day in advance of the filling, so the silage cutter is kept busy without using two binders or an unusually large crew of hand cutters.

Cutting in the field is the most important operation when field harvesters are used since the corn is also cut into silage lengths at the same time and the speed of this operation determines the rate of filling. All the power-take-off field harvesters and all the horse-drawn

motor-mounted machines were operated by one man. An average of 1.43 hours was used in cutting an acre with power-take-off machines, and an average of 1.57 hours was used with the motor-mounted horse-drawn machines. Motor-mounted machines were pulled by tractors instead of horses on 10 farms, but two men were necessary, and the rate of cutting was not increased. It was, therefore, not an economical practice.

HAULING CORN TO THE SILO

Nearly 50 percent of all labor used in filling silos with stationary cutters is employed in the operation of loading the corn on the wagon, hauling to the silo, and unloading at the cutter table. Many operators are willing to add some to the cost of filling if this operation can be made easier, but little change can be made except through the use of labor-saving equipment. Low-wheeled wagons or special wagons

FIGURE 3.—Cutting corn with a binder equipped with a bundle elevator.

with low-slung racks make the loading somewhat easier but make unloading more difficult since the corn must then be lifted to the cutter table.

The method of cutting in the field has a direct bearing on the ease of handling the corn and on the number of men required in hauling. Bundle corn can be handled more rapidly and with more ease than the loose corn, particularly if the bundles are made small enough to be handled easily. An average of 1.14 hours of labor was used per ton in loading and hauling corn which had been cut by hand as compared with 0.93 hour where the corn was cut with a binder and the bundles dropped on the ground.

Extra pitchers are often used to help load the wagons in the field, especially when custom machines are hired and the aim is to fill as rapidly as possible without adding more teams and wagons. This makes the work easier on the haulers but increases the size of the crew and the total amount of man labor used. On farms on which each hauler loaded his own wagon an average of 0.91 hour of labor per ton was used in hauling, while an average of 1.21 hours was used where

extra pitchers were employed. But an average of 1.28 tons of silage was hauled per hour on each wagon when extra pitchers were used, as compared with 1.10 tons when each man loaded his own wagon.

Bundle elevators eliminate entirely the work of lifting the corn to the wagons. Two or more binders are often necessary, however, and extra men to drive the wagon teams enable the haulers to load the bundles properly without stopping the binder. This increases the total amount of man labor used but also increases slightly the rate of filling with the same number of wagons and teams. An average of 0.72 hour of man labor per ton was used in hauling when each hauler drove his own team, and an average of 0.83 hour was used when extra drivers were employed; but the quantity of silage material hauled per hour on each wagon was increased from 1.38 to 1.66 tons.

The field harvester eliminates all the heavy work of loading and unloading the whole corn since the cut corn is elevated into box wagons drawn alongside the machine, and is pushed or shoveled out of the back of the wagon into the blower hopper at the silo. If a wagon hoist is available it is used to lift the front end of the wagon, thus letting the corn slide into the hopper. If the distance to the field is not great, 3 or 4 men can haul the chopped corn as fast as it can be cut. An average of 0.58 hour of man labor was used per ton in hauling from the field to the silo. One great advantage of the field harvester is that a less able class of labor can be utilized. On many farms the older men and younger boys who could not be efficiently used around a stationary cutter make full hands here, and usually their wage rates are lower.

OPERATING THE TRACTOR AND CUTTER OR BLOWER

The rate of filling with stationary cutters is determined on most farms by the number of men hauling corn and the rate at which they feed the cutter. The number of men at the machine usually varies with the kind of power unit, the type of cutter, and the number of men hauling. Only in cases where large cutters and large crews are used is the number of men operating the machine a factor limiting the rate of filling.

The wages of 2 men, who operate the tractor and cutter, are usually included in the amount charged for custom machines, but 1 man usually tends both if the equipment is owned on the farm. One man can operate the tractor and blower, elevating the silage material as fast as the corn can be cut with a field cutter, but in some cases each hauler unloads his own load, and no one stays at the silo. Less labor is used by this method, but it is not a good practice unless someone definitely is responsible for the care of the tractor and blower.

The total amount of labor used in operating the tractor and stationary cutter, or blower when a field harvester is used, depends on the number of men and the rate of filling. An average of 0.23 hour per ton was used in operating the tractor and stationary cutters and the tractor and blower on farms where field harvesters were used. The amount used on individual farms varied a great deal, but on an average the difference in number of men operating the tractor and cutter or blower was balanced by differences in the rate of filling.

TRAMPING SILAGE AND MISCELLANEOUS WORK

Tests have shown that tramping is not necessary for making good silage. But the silage must be tramped if as much corn as possible is to be put into the silo without refilling, especially when the filling is done rapidly. A silo with a capacity of 120 tons on one farm was filled in 1 day with no tramping, and after the material had settled for a few days was not over three fourths full. When 2 or more days are used in filling, the silage settles from its own weight, and tramping becomes less important. On the farms studied the number of men used in tramping ranged from none to 5, 1 man being most commonly used where stationary cutters were owned, and 2 men where custom machines were hired. On 44 percent of the farms on which field harvesters were used the silage was not tramped, and 1 man was used for this work on about the same number of farms.

Setting up the machine, chore work, and making repairs made up less than 5 percent of the total labor used in filling with stationary cutters, and about 9 percent of that used in filling with field harvesters. Much of the chore work can be done when the entire crew is not on the job, but repairs that hold up the entire crew increase the amount of man labor used and likewise the cost of filling.

FUEL AND OIL

The cost of fuel and oil used in silo filling varies with the method of filling, the kind and size of the power unit, the rate of filling, the general running condition of the equipment, and other factors. The average quantities used with different equipment on the farms are shown in table 2. More fuel is required in filling with field harvesters than with stationary cutters since two power units are necessary and the amount of time is not reduced. From 25 to 30 percent more fuel was used in three-plow tractors than in two-plow tractors, and nearly two and a half times as much fuel was used when motor-mounted field harvesters were pulled by tractors. Less fuel is used in filling with stationary cutters when the rate of filling is relatively high, but the yield of silage material per acre is a more important factor when field harvesters are used.

TABLE 2.—*Quantities of fuel and oil used in filling upright silos with stationary cutters and field harvesters, 1928 and 1929*

Equipment used	Farms	Yield per acre	Silage cut per hour	Quantities used per 100 tons of silage	
				Fuel	Oil
	Number	*Tons*	*Tons*	*Gallons*	*Gallons*
Stationary cutters:					
2-plow tractors [1]	24	7.6	6.6	30.0	1.63
3-plow tractors [1]	48	7.6	7.7	37.6	1.53
Field harvesters:					
Power-take-off cutters:					
2-plow tractors	13	7.8	5.6	30.4	1.41
3-plow tractors	24	8.3	5.7	36.6	1.39
Motor-mounted cutters:					
Horse-drawn [2]	49	8.2	5.2	22.7	2.26
Tractor-drawn	10	9.4	5.2	56.0	4.14
Blowers:					
2-plow tractors	58	8.4	5.5	26.9	1.31
3-plow tractors	38	8.0	5.3	35.8	1.71

[1] For the purpose of this study, tractors with ratings of 12–27 horsepower or larger were considered as 3-plow tractors, while those with lower ratings were considered as 2-plow tractors.
[2] Includes that used in the tractor and in the motor on the cutter.

Usually there is no alternative in the kind of fuel except as gasoline and kerosene are interchangeable, since the available power unit must be used. The use of tractors in pulling motor-mounted field harvesters and binders is not common and is not an economical method under usual conditions. The amount of fuel used and filling costs are reduced by having the power unit and cutter in proper adjustment and in condition to operate efficiently, and by cutting at a speed that makes the maximum use of the available power.

TWINE

Twine is an element of cost in filling silos when the corn is cut with a binder and handled in bundles. The amount used per acre varies with the weight of the crop, the range being from 2.75 pounds per acre for yields between 4 and 6 tons, to about 4.5 pounds per acre where the yield is from 12 to 14 tons per acre. On the farms on which the corn was cut with a binder and bound, the average yield of silage material was 7.5 tons per acre and the average amount of twine used was 3.3 pounds per acre, or approximately 0.44 pound per ton.

COST OF FILLING SILOS

The selection of a method of filling silos is a practical problem with which each silo owner is concerned. If no equipment is owned he must give consideration to such problems as the ownership of the equipment with which he fills his silo, the type of equipment, the method of cutting corn in the field if a stationary cutter is used, and the size and organization of the crew. On some farms no alternative may be open to the operator; then such factors as available capital, power available on the farm, and the capacity of the equipment determine the kind and ownership of the equipment. On most farms, however, the choice is determined largely by relative costs.

The average costs of filling on the farms studied are shown in table 3. Average costs on farms where stationary cutters were owned and where they were hired are shown, as well as costs for two classes of field harvesters, the power-take-off machine and the motor-mounted type. The costs are first itemized in detail and are then combined in four divisions according to their nature and significance in determining the cost of operating the farm. Before the costs in table 3 are discussed this classification may be examined.

CLASSIFICATION OF COSTS

"Direct cash costs" include hired labor, fuel and oil, twine, repairs on equipment, and custom charges paid for the use of hired equipment. Under all circumstances such costs have a direct influence on the decision of the farmer since they add to the immediate cost of operating the farm.

"Unpaid costs", as here used, include the assigned value of those elements contributed by the farmer himself and his family, and the permanent elements in the organization of his farm. Proprietor and family labor, the use of work stock regularly kept on the farm, and the use of farm buildings for housing equipment, are included in this group. It is true that these costs eventually must be met in full if farming is to be profitable, but the cost of operating the farm is not necessarily increased by making maximum use of these permanent elements in the farm organization. Alternative opportunities for using these elements may make their cost of greater importance.

TABLE 3.—*Cost of filling upright silos with stationary cutters and field harvesters, based on average amounts of labor, power, and materials used in Illinois, 1928 and 1929*

Item	Farms on which stationary cutters were used		Farms on which field harvesters were used [1]	
	Owned machines	Hired machines	Power take-off machines	Motor-mounted horse-drawn machines
Farms—number	47	40	39	49
Area cut per farm—acres	17.5	14.5	21.5	14.4
Yield per acre—tons	7.6	7.3	8.2	8.2
Itemized average costs per 100 tons of silage: [2]				
Hired labor—dollars	35.15	32.02	19.47	19.57
Unpaid labor—do	35.15	32.02	29.21	29.35
Horse work—do	29.33	30.57	15.24	24.55
Tractor:				
Depreciation and repair—do	9.22	2.17	16.71	9.14
Interest—do	4.97	1.17	9.00	4.92
Stationary cutter:				
Depreciation—do	5.00			
Interest—do	2.40			
Repairs—do	1.95			
Binder:				
Depreciation—do	3.66	4.23		
Interest—do	1.46	1.45		
Repairs—do	.62	.59		
Field harvester:				
Depreciation—do			15.24	15.18
Interest—do			5.94	5.92
Repairs—do			1.91	2.21
Field harvester blower:				
Depreciation—do			3.03	3.00
Interest—do			2.26	2.25
Repairs—do			.22	.68
Fuel and oil—do	6.35	5.56	10.81	11.80
Twine—do	3.50	4.43		
Wagon use—do	1.67	1.62	1.23	1.23
Building charge—do	.68	.44	.88	.88
Custom charge—do		32.40		
Total cost—do	141.11	148.67	131.15	130.68
Classified and combined cost per 100 tons of silage: [3]				
Direct cash costs—dollars	47.57	75.00	32.41	34.26
Unpaid costs—do	65.16	63.03	45.33	54.78
Depreciation—do	19.55	8.02	36.21	28.55
Interest—do	8.83	2.62	17.20	13.09
Total cost—do	141.11	148.67	131.15	130.68

[1] Data from 20 farms where machines were hired and from 10 farms where motor-mounted machines were pulled by tractors were not used in estimating these costs.

[2] The following rates for labor, power, and materials were used to determine the cost of filling silos in 1928 and 1929: Man labor, 40 cents per hour; horse work, 14 cents per hour; tractor use, 90 cents per hour for 3-plow size and 40 cents for 2-plow size, 65 percent of which was depreciation and repairs and 35 percent of which was interest; fuel, 13.4 cents per gallon for kerosene, 16.4 cents for gasoline, and oil at actual cost; twine at actual cost; and wagon use at 2 cents per hour. An average life of 15 years was estimated for the stationary cutters, during which time an average of 500 tons is cut each year. With an average initial cost of $375, a charge of 5 cents a ton was made for depreciation and 2.4 cents for interest. Binders were estimated to have a life of 12.5 years, cutting 40 acres each year and having an average intiial cost of $175, or $225 when bundle elevators were used; a charge of 35 cents was made per acre when no elevator was used and one of 45 cents when the elevator was used. On the basis of estimates made by the operators, field harvesters were estimated to have an average life of 12 years, cutting a total of 500 acres during that time. The average price paid for the machines was about $625. Depreciation was charged at $1.25 per acre and interest at 48.75 cents an acre. By the same method the average life of the blower was estimated as 24 years, during which time it would put up 7,500 tons of silage. The initial cost was $225; depreciation was charged at 3 cents per ton and interest at 2.25 cents per ton. The allocated cost of housing the field harvester and blower was estimated at $3 per year.

[3] Direct cash costs include hired labor, repairs, fuel, and oil, twine, and custom charges. Unpaid costs include operators' and other family labor, horse work, and building charges. Depreciation includes depreciation and repairs on the tractor, depreciation on the stationary cutters, field harvester and blower, and binder, and wagon costs. Interest includes interest on the tractor, stationary cutter, field harvester, blower, and binder.

On many farms depreciation is very similar to the unpaid costs. Depreciation represents a cash outlay at some previous time, but once the equipment is bought its use does not represent a cash expense exclusively for the operation concerned—filling silos in this case. Depreciation, as a replacement cost, usually is distributed over the life of the equipment, but, in an emergency, its consideration often may be deferred. Furthermore, a certain amount of depreciation takes place through weathering and obsolescence, even though the equipment is not used. Depreciation on such equipment as tractors, binders, and silo-filling equipment, which have many wearing parts and on which repairs are costly, are more important than on many simpler machines. Although it may be disregarded during a single year on farms where such equipment is already owned, it should be considered carefully by the operator who is considering the purchase of new equipment.

Finally, there is interest, which might also be considered as unpaid costs, but which is put in a separate classification in order to make the picture a little clearer. The purchase of new equipment increases the amount of capital invested in the farm business on which interest must be paid or from which some return may be expected. Additional use of equipment already on the farm, however. does not increase the total annual interest charge to the farm.

USE OF COST DATA IN SELECTING A METHOD OF FILLING SILOS

The average cost of filling silos with stationary cutters on the farms studied was $1.41 per ton when the equipment was owned by the farm operator and $1.49 per ton when a custom machine was hired. It cost $1.31 per ton to fill with a field harvester, either a power-take-off or motor-mounted type. These average costs include all of the items that have been discussed—direct cash costs, allowance for depreciation and interest on equipment, the assigned value of the operator's labor and that of his family, cost of housing the equipment, and the cost of horse work.

Do these average costs give conclusive answer to each individual farmer's question of how he shall fill his silo? If he has in the past hired a custom machine to fill his silo, can he conclude that he can save 18 cents a ton by buying a field harvester, or that he can fill with a field harvester for 10 cents a ton less than if he owned a stationary cutter? Not at all. The cost data presented in table 3 represent the average on many farms on which conditions varied greatly. They cannot represent accurately the costs on a specific farm.

In the first place the relative prices paid for labor and materials vary from farm to farm and from year to year. In determining the feasibility of buying equipment, relative costs must be calculated on the basis of prices existing on each farm. In the second place both the total costs and the relative importance of the different classes of costs vary with conditions on each farm. In addition to conditions which affect the money cost of filling, such factors as the operator's personal preference as to exchanging labor with neighbors, the customs in the community, and alternative uses for capital, labor, and power often must be considered.

The use of field harvesters involves the substitution of power and equipment for a large part of the man labor used in filling with

stationary cutters. Man labor (table 3) makes up nearly 50 percent of the total cost of filling with the owned stationary cutter, 43 percent when one is hired, and 37 percent when the field harvesters are used, while depreciation and interest on equipment equaled 20 percent, 7 percent, and 30 to 40 percent, respectively. A reduction of one half in the cost of man labor, with other costs remaining the same, would make filling with stationary cutters cheaper than filling with field harvesters. On an average, the use of custom machines increases the cost of filling and particularly the direct cash cost, but in many cases a machine may be obtained in exchange for labor or power, which at that time has little alternative use, and at a lower cost than if a cutter were owned.

The importance of some costs, as shown in table 3, may be discounted on some farms and under certain economic conditions. Under conditions existing in recent years, it is particularly important that cash costs be kept at a minimum. The average cash cost of filling with field harvesters in 1928 and 1929 was about 33 cents a ton as compared with 48 cents on farms where stationary cutters were owned and 75 cents when custom machines were hired. Depreciation, which represents replacement costs, may be disregarded for a year or so, but should be considered in determining the costs of filling over a period of years. Direct cash costs and depreciation amounted to more than 68 cents a ton when the modern power-take-off field harvester was used in 1929 as compared with 67 cents where a stationary cutter was owned.

Unpaid costs and interest may enter into the consideration in an entirely different way from cash costs or depreciation. These costs should be considered, but in the immediate situation the individual farmer may be willing to use his own and other family labor, and his capital, without the hope of getting the desired return for its use. He may decide to do this merely because if he does not he will get nothing for it and he feels that a small return is better than nothing. Alternative uses for this labor and capital, therefore, are an important consideration in determining the value the farmer places on their use.

FACTORS AFFECTING THE COST OF FILLING SILOS

Average costs, such as are shown in table 3, represent the combined effect of a great number and variety of conditions, and cannot be expected to indicate relative costs on an individual farm under certain conditions. Some of the factors affecting the costs and the relative importance of the different classes of costs are (1) quantity of corn cut, (2) yield per acre, (3) amount of regular labor available on the farm, (4) cost of hired labor, and (5) alternative uses for labor, power, and capital.

The amount of use made of silo-filling equipment affects the different classes of costs in different ways. The costs of hired labor, fuel, twine, and custom charges increase directly with the quantity of silage material cut. Depreciation costs increase with the amount of use made of the equipment but at a lower rate, since weathering and obsolescence become relatively less important as the equipment is used more. The amount of capital invested depends on the kind of equipment. Only a small amount is required if a custom machine is hired, while a field harvester costs considerably more than a stationary cutter. Interest charges, therefore, do not increase with the amount of time which the equipment is used. "Unpaid costs" increase with

the quantity of silage material cut, but little importance should be attached to them if there is no other productive work on which family labor and the available horsepower could be used at the time when the silo is being filled. Thus, on a farm on which a small quantity of silage material is cut, cash costs would be doubled if twice as much silage material were cut, but depreciation charges would not be increased proportionately, interest charges would show no increase, and the additional unpaid costs might be considered of little importance under the conditions. On some farms on which only a small quantity of silage material is cut, these overhead costs are reduced by doing custom work, by filling in exchange for labor, or through cooperative ownership of equipment.

The yield of corn per acre is a factor in determining not only the cost of filling from farm to farm with the same type of equipment but also the relative cost by different methods. As the yield per acre decreases, the necessary number of men cutting corn, either by hand or by machine, and the number hauling the corn to the silo, must be increased if the same rate of filling is maintained. This additional help usually must be hired; so low yields affect particularly the cash costs. Yield is more important when the filling is done with a field harvester than when a stationary cutter is used, since the rate of filling is determined by the quantity of corn cut per hour by the field cutter. Less time is required to cut an acre in low-yielding corn, but the quantity of corn cut per hour is reduced. More fuel and oil are used and depreciation on the field cutter increases with the acreage cut regardless of the yield, resulting in higher costs per ton of silage.

One of the greatest advantages of the field harvester is the small crew necessary to operate the machine at full capacity, making it possible to use regular farm labor to a greater extent. Family and regular hired labor made up 52 percent of the total labor used on farms where field harvesters were owned as compared with 28 percent where stationary cutters were owned and 14 percent were stationary cutters were hired. More time is required to fill, but the cash cost is materially reduced unless extra labor must be hired to return the exchange labor. A further advantage is the possibility of using labor that could not be used in filling with a stationary cutter. For example, one field harvester on which information was obtained was owned by two brothers living on adjoining farms. One year these 2 men, their father, 2 boys, and 1 hired man filled their 2 silos with a combined capacity of 231 tons in 32.5 hours. Neither the father nor the boys could have helped much in filling with a stationary cutter, but made full hands in driving the wagons since no heavy work was involved. On another large dairy and beef cattle feeding farm, on which 8 to 10 men were regularly employed, and on which several large silos had to be filled, a field harvester had been discarded. It was found that the available labor was more efficiently utilized and the filling was accomplished in less time with a medium-sized stationary cutter.

The relation of the cost of hired labor to the total cost varies with the method of filling. Hired labor, as shown in table 3, makes up about 21 percent of the total cost of filling with a custom outfit, 25 percent where a stationary cutter is owned, and less than 15 percent where a field harvester is used. The relative advantage of the field harvester is greatest, therefore, when the price of hired labor is high and the possibility of using less able and less expensive labor increases this advantage.

The choice of equipment may be influenced and the relative costs of filling determined by the amount available or by alternative uses for the available capital, labor, and power. No capital is invested if a custom machine is hired, but the cash costs are higher. The effect on the farm income, if these elements of production are used in other phases of the farm business, may determine their value in filling silos. Capital invested in other equipment or improvements may return a greater income than if used to purchase a silo filler. Family labor and horse work are important items of cost only if they may be used in other work, at that time, which would increase the farm income or decrease the operating expenses of the farm.

The ease of filling or amount of leisure time may be considered on farms where costs by different methods appear similar. The usual custom in the community or consideration for neighbors may also be important in some instances. On 1 farm 2 silos, each with a capacity of 256 tons, were filled. The large quantity of silage made it almost impossible for this man to exchange labor with his neighbors. A new field harvester would have necessitated hiring another tractor and would not have reduced the time used very much. The operator, 2 regularly hired men, and 2 extra hired men filled these silos in 125 hours with a 16-inch stationary cutter, cutting the corn in the field with a binder equipped with an elevator.

The effect of these factors on the total cost of filling by different methods and on the distribution of costs may be seen more easily by making some estimates on a single farm. On one of the farms studied a custom machine was hired to fill a silo holding 175 tons. A custom charge of $4 per hour, plus the cost of fuel, was paid for the tractor and cutter, and the labor of two men. Labor was exchanged with four other farmers in the community and, in order to fill as rapidly as possible, a crew of 15 men was used in addition to the machine men. A total of 67.5 hours was required to fill the 5 silos, and since only the operator was on the farm at this season of the year it was necessary to hire 2 men for the entire period. The costs of filling with the custom machine and the estimated costs if a stationary cutter or a field harvester had been owned are shown in table 4. It is estimated that with his own stationary cutter this farmer can cooperate with only 3 other men and fill the 4 silos in 72 hours with a crew of 10 men. In case the field harvester was owned, the cooperation of only 1 other is desirable, and with 6 men the 2 silos will be filled in 48 hours. One difficulty with individual ownership of the field harvester is the necessity for two tractors. In this case it may be agreed that each farmer will furnish a tractor and that the farmer cooperated with will pay the estimated depreciation costs on the field cutter and blower in filling his silo. As these costs will about equal the cost of hiring a tractor, neither is included in the costs shown.

The estimated costs, based on prices prevailing in 1929, were $1.17 per ton when a custom machine was hired and would have been $1.08 if a stationary cutter had been owned and $1.05 if a field cutter had been purchased. Cash costs were even more in favor of the field harvester, being 77 cents per ton when a custom machine was used, 45 cents with an owned stationary cutter, and 36 cents with a field harvester. Depreciation and interest, however, are greatest when the field harvester is used and amount to only a small part of the total cost when a machine is hired. Under these conditions costs are in

favor of the field harvester. What will be the effect on these costs and their distribution (1) if only half as much silage is cut; (2) if the yield of corn per acre is materially different; (3) if more unpaid labor is available, and (4) if labor and material costs are changed?

TABLE 4.—*Cost of filling a 175-ton silo with a custom machine on one farm in 1929, and estimated costs if a stationary cutter and field harvester had been owned*

Item	When hired stationary cutter was used	If owned stationary cutter had been used	If owned field harvester had been used
	Dollars	*Dollars*	*Dollars*
Cash costs	135.28	78.21	63.02
Unpaid costs	53.85	57.20	36.60
Depreciation	10.21	29.49	49.96
Interest	5.67	23.34	34.89
Total	205.01	188.24	184.47

If only 87.5 tons of corn were cut, all costs, with the exception of interest, presumably would be reduced accordingly. But interest makes up only 2.8 percent of the total when a machine is hired, 12.4 percent when a stationary cutter is owned, and 18.9 percent when a field harvester is owned. So far as total costs are concerned, therefore, the custom machine would be the most economical method, while the field harvester is the most expensive. Cash costs, likewise, are reduced by half when a field harvester is owned unless the smaller quantity of corn enabled the operator to return a greater part of the exchange labor with unpaid labor, in which case the costs would be reduced more than half.

A lower yield of corn per acre would increase the acreage of corn required. More labor and power would be used in cutting the corn and depreciation on the binder would be increased accordingly when stationary cutters are used. The rate of filling would also be reduced unless additional labor is hired for cutting and hauling corn. If the yield is reduced one third, the cost of filling with the custom machine is increased about 12.4 percent and with an owned cutter about 14.1 percent. In the case of the field harvester, however, depreciation on the tractor and field cutter would be increased 50 percent, and nearly 50 percent more fuel would be used. Not more than five men would be needed, since the rate of cutting would be lower, but the total labor bill would be increased nearly 10 percent, while slightly less horse work would be used. The total cost, however, is increased about 22.5 percent and is more than if a stationary cutter is owned and nearly as much as if one is hired. Yield is important, therefore, in determining the relative economy of the field harvester.

The amount of family labor available does not affect the total cost but does affect the amount of hired labor and thus the cash cost of filling. If there were two unpaid members of the family, the cash cost of filling with the custom machine would be reduced $27, with the owned stationary $28.80, and $19.20 if a field cutter is used. Not only family labor but regular hired labor, which would be paid even if the silo were not filled, should be considered in this way.

The cost of hired labor affects both total costs and their distribution. Labor costs make up a larger proportion of the total when stationary cutters are used; so low-cost labor reduces the advantage of the field

harvester. If labor can be obtained at 25 cents an hour instead of 40 cents, the cost of filling with the stationary cutters on this farm is reduced nearly 15 percent but less than 12 percent in the case of the field harvester. The possibility of using less-able labor, boys, or elderly men, with the field harvester, however, always offers a chance of further reducing the cost of filling with the field harvester.

ORGANIZATION OF CREW FOR FILLING SILOS

The size and organization of the crew used in filling silos should be determined by the type of equipment used, the amount of unpaid labor and exchange labor available, the cost of hired labor, and the amount of time available for filling.

The rate of filling with the field harvester is determined by the capacity of the field cutter, and three or four men with teams can almost always haul the chopped corn from the field to the silo as fast as it is cut. One man usually is kept at the silo to tend the tractor and blower,

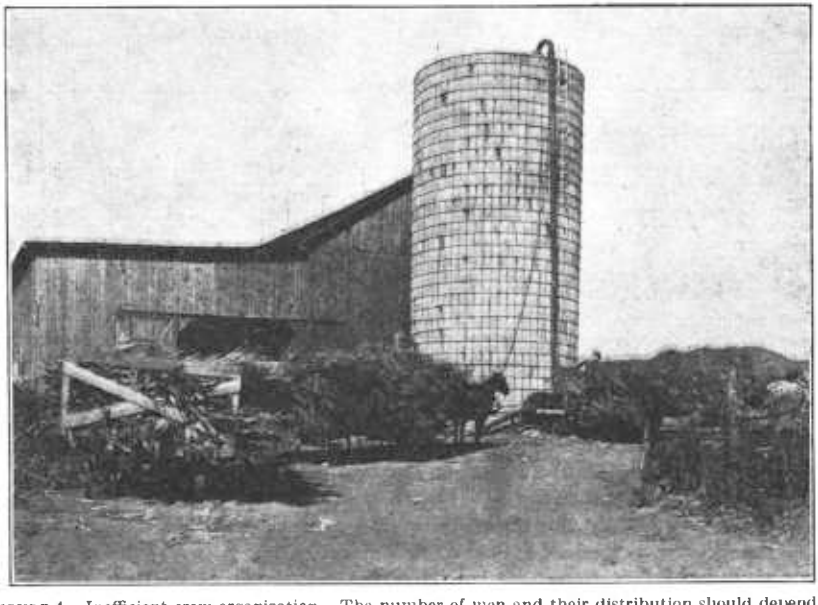

FIGURE 4.—Inefficient crew organization. The number of men and their distribution should depend on the capacity of the cutter so that there will be a minimum amount of waiting.

help unload, and put doors in the silo. Tramping is considered unnecessary in filling with the field harvester since the lower rate of filling usually gives sufficient time for the material to settle from its own weight. The most efficient number of men is not so difficult to determine when this type of equipment is used.

The organization of the crew used in filling with the stationary cutter is not so simple. Except in cases where very small cutters are used or where sufficient power is not available, the number of men hauling corn from the field is the limiting factor in determining the rate of filling. The necessity or desire of the silo owner to fill slowly or rapidly should determine the size of the crew in most cases (fig. 4). Where a custom machine is hired and the cost determined by the amount of time used, a large crew is economical in most cases.

If a machine is owned, however, and no other work at which the regular labor can be more effectively used is available, the cash cost usually is reduced by filling more slowly with a small crew in order to use unpaid or exchange labor as much as possible.

The approximate quantity of corn that one man with the usual power unit may be expected to handle per hour is shown in table 5. The rate of cutting corn in the field is especially affected by the yield per acre, but the quantity of corn hauled per man is also affected, so the data in table 5 are adjusted for corn yielding about 8 tons of silage per acre. As the rate of performance is also affected by other factors such as the distance the corn is hauled, the type of corn, and size of crew in relation to size of cutter, the expected range, due to these factors, is also shown.

TABLE 5.—*Approximate quantities of corn handled per unit of man labor and power in corn yielding 8 tons of silage material per acre* [1]

Operation and method	Quantity per unit	Expected range in quantity	Operation and method	Quantity per unit	Expected range in quantity
	Tons	*Tons*		*Tons*	*Tons*
Cutting corn in field by hand	1.6	1.0–2.2	Hauling corn cut with binder with elevator:		
Cutting corn in field with binder:			Without extra drivers	1.5	1.2–1.8
Without elevator	5.4	4.4–6.4	With extra drivers	1.6	1.4–1.8
With elevator	4.4	3.4–5.4	Cutting corn with power-take-off field harvester	5.8	4.0–7.6
Hauling corn cut by hand:			Cutting corn with motor-mounted field harvester	5.2	4.2–6.2
Without extra pitchers	1.0	.7–1.3			
With extra pitchers	1.2	.9–1.5			
Hauling corn cut with binder without elevator:					
Without extra pitchers	1.3	1.0–1.6			
With extra pitchers	1.4	1.1–1.7			

[1] One unit of man labor, and power consists of 1 man plus 2 horses in hauling corn, 3 horses in cutting with a binder or motor-mounted field harvester, or 1 tractor in the case of the power-take-off field harvester, the combination working 1 hour.

Given a farm on which a medium-sized stationary cutter is owned with sufficient power and labor available to fill a 180-ton silo in 2 days or about 18 hours; how many men will be needed, and how must they be distributed if the corn is cut with a binder and the bundles dropped on the ground?

A study of the figures in table 5, indicates that 2 binders are necessary to complete the job in the time specified, or 1, if it cuts 1 entire day before filling is started. Since 1 man can haul about 1 ton per hour, 10 men with teams and wagons are necessary, or if 2 or 3 extra pitchers are provided to help load the wagons in the field, 8 men may be sufficient. Two men should be kept at the silo when cutting at this rate, 1 to feed the cutter and 1 to tend the tractor and cutter. In order to fill the silo fairly full at least 2 men should tramp; and there probably should be 1 man to put in doors, tend the water, and do other miscellaneous tasks.

This arrangement makes a crew of at least 17 men. More will be needed if the distance from the field to the silo is unusually great or if the yield of corn per acre is lower. If the corn is cut by hand, 6 men are necessary in cutting unless some corn is cut the day before. If binders with the elevator attachments are used, three binders probably will be necessary, but not more than 7 men will be needed for hauling.

The size of crew probably is more often determined by the number of men available than by the speed at which it is desired to fill. Suppose 10 men are available on this farm; what should be their distribution? One man must tend the cutter and tractor, 2 men should tramp, put in doors, etc., while 1 man with a binder can cut the corn. This would leave 6 men to haul corn, and the silo would be filled at the rate of about 6.5 to 7.5 tons an hour. Since one binder can cut only about 5.5 tons an hour some cutting must be done the day before. If elevator attachments are used on the binders, two binders would be necessary, and 5 men would be left to haul corn to the silo. The 5 men could not keep both binders cutting steadily, but this would be preferable to using one binder and delaying the haulers.

The organization of the crew is an important factor in obtaining economic and efficient operation. The choice of equipment is made only once in several years, but the most efficient crew must be determined each year, on the basis of local conditions.

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U. S. GOVERNMENT PRINTING OFFICE: 1934

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